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The Learning Research and Development Center, an institute composed of faculty from the University of Pittsburgh, has as its general purpose the scientific study of the problems of learning and instruction. Particular attention is given to the nature of the educational and psychological environment required to maximize the potential of the individual learner. The Center's activities range from basic theoretical studies of the learning process; through the development of procedures, materials and equipment of instruction; to the development of educational programs in school settings. The four major programs described are (1) Basic Learning Studies, (2) Computer-Assisted Instruction Studies, (3) Field Research, and (4) Experimental School Development. For each of the major programs, one or two illustrative projects are describes: (1) language comprehension skills and response latency characteristics in learning, (2) curriculum design for computer-assisted instruction, (3) computer management of individualized instruction and studies of learning rate and (4) experimental school operations concerned with individually prescribed instruction and curriculum design in early learning. (Author/LS)

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The Learning Research and Development Center at the University of Pittsburgh

John L. Yeager and Robert Glaser

Abstract

The general goals, programs, and illustrative projects of the Learning Research and Development Center at the University of Pittsburgh are described. The Center's general purpose is the scientific study of the problems of learning and instruction with particular attention to the nature of the educational and psychological environment required to maximize the potential of the individual learner. The Center's activities range from basic theoretical studies of the learning process; through the development of procedures, materials and equipment of instruction; to the development of educational programs in school settings.

The four major programs described are (1) Basic Learning Studies, (2) Computer-Assisted Instruction Studies, (3) Field Research, and (4) Experimental School Development. For each of the major programs, one or two illustrative projects are described: (1) language comprehension skills and response latency characteristics in learning, (2) curriculum design for computer-assisted instruction, (3) computer management of individualized instruction and studies of learning rate and (4) experimental school operations concerned with individually prescribed instruction and curriculum design in early learning.

The Learning Research and Development Center at the University of Pittsburgh[1]

John L. Yeager and Robert Glaser

Purpose and Goals

The Learning Research and Development Center is an institute composed of a faculty from many different academic departments of the University of Pittsburgh. Its general purpose is the scientific study of the problems of learning and instruction with particular attention to the nature of the educational and psychological environment required to maximize the potential of the individual learner. The scope of its activities ranges from basic theoretical research on the learning process; through the development of procedures, materials, and equipment of instruction; to the development of educational programs in school settings for experimentation, tryout, and evaluation. The role of the Center is to provide the climate, the organization, and the facilities for maximizing fruitful interaction between relevant academic disciplines and the study of learning and educational practice. The broad goals of the Center are the following:

1. To contribute to the growth of those aspects of behavioral science which are relevant to educational practice. A major rationale of the work of the Center is that research in the behavioral sciences can provide foundations for new educational practices and that researchers sensitive to this possibility can make contributions both to their underlying science and educational research and development. This span of activity fosters a constant interplay between instructional implementation and basic experimental work, each providing insights and substance for the other.

2. To develop effective prototype models of instructional procedures and appropriate hardware and software through the involvement of scientists, engineers, and educators. An operating principle of the Center is the belief that if the results of the study of learning by the researcher are to have practical implications for education, these implications can best be translated into instructional procedures and materials under the direction of the researcher himself. The Center, therefore, encourages the researcher also to be a developer of prototype instructional materials.

3. To develop and evaluate experimental instructional systems, including materials, procedural components, and personnel training. Coordinate with its research emphasis, the Center contributes to educational improvement through the development of evaluated systems of instruction. An operating principle is that effective educational change comes about most rapidly through the development and demonstration of full-blown programs which include the necessary material, teacher training, and environmental design to make them operational in a school setting. As programs are developed, they are continually evaluated through the collection of data which provide evidence of the effectiveness of the program and which in turn are analyzed in such a way as to provide specific implications for the further improvement of the program. It is the Center's policy that its work in school settings is performed for the purposes of research and development; it does not act as a service agency, as such, for the maintenance of ongoing programs.

Research and Development Programs

The Center's activities are carried out in the context of four program areas: (1) Basic Learning Studies, (2) Computer-Assisted Instruction Studies, (3) Field Research, and (4) Experimental School Development. The four program areas provide a context in which different activities can operate and also can exchange appropriate information and personnel. Under each of these program areas are a number of specific projects in which work is carried out. Figure 1 presents a current representation of the four programs and the projects in each.

Basic Learning Studies. In the Basic Learning Studies Program, psychologists and other behavioral scientists conduct research on learning that may be basic to the development of instructional materials and procedures. Since basing educational practice on the science of learning is an important goal of the Center's total program, independent scientists working with small research staffs are investigating a variety of learning phenomena. These basic research studies are carried out in a laboratory context which permits the investigator to achieve a greater degree of control and precision than is normally found in classroom studies. For some experiments, a computer facility in the Center is employed to carry out investigations on-line under computer control. The types of problems that have been investigated include: the properties of response latencies in rote learning (Judd, 1968); the study of the nature of attention through analysis of eye movements (Schroeder & Holland, 1968a, 1968b); the analysis of comprehension skills (Resnick, 1968); study of transfer effects in verbal learning (Kjeldergaard, 1968); and the acquisition of discriminations in young children (Cohen, Glaser & Holland, 1968).

In addition to laboratory studies, many of the researchers are working on developmental activities which are concerned with the application of basic principles to the production of educational materials and procedures, e.g., beginning reading materials (Kjeldergaard, Frankenstein, & Kjeldergaard, 1967), the behavioral analysis of student-teacher interaction, and preschool skills development programs. This duality of research and development activities involving a single researcher permits a work context that assists in providing sustained relationships between basic research and development.

Computer-Assisted Instruction Studies. The second program area, that of Computer-Assisted Instruction (CAI) Studies conducts research and development on computer-assisted instructional systems (Ragsdale, 1966). This program is concerned with: (a) the analysis of learning processes as students work in partially automated environments, (b) the design of experimental student stations, (c) the study and development of effective CAI courses, and (d) the evaluation of the potential role of CAI in a range of educational applications. A potential contribution of computer-assisted instruction is to provide the learner with a highly responsive learning environment in which he can manipulate subject matter problems in a more interactive way than has heretofore been possible with the usual materials of education. In working on this problem the Center is interested in and is experimenting with the use of cathode-ray tube displays, specially designed touch-sensitive displays, devices for rapid access to audio and visual displays and a variety of other interface devices (Glaser & Ramage, 1967; Blackhurst,

1965). Engineering research being carried out in this program involves not only the study of how such devices can be used most effectively in instruction, but also of how they can be developed and be economically feasible. Attention is also given to instructional systems management and data processing concerned with the gathering, storing, and retrieving of relevant data on individuals and curricula, and with the decision algorithms which utilize these data (Klahr, 1967).

Field Research. The research in this program is oriented toward basic problems in educational and psychological measurement, including activities in curriculum evaluation and in the assessment of learner behavior relevant to the planning and redesign of instructional systems (Lindvall, 1966). Attention is also given to assessment of the effects of socio-psychological variables on learning outcomes (Brodie & Suchman, 1967). In the context of the Center's experimental school activities, psychometric methods are brought to bear on learning problems in the form of the design of procedures for the assessment of educational objectives, (Cox and Graham, 1966), for the analysis and diagnosis of individual differences relevant to alternative teaching procedures (Glaser, 1968), for the measurement of classroom environments (Yeager & Lindvall, 1968), and for the analysis of curriculum materials and instructional practices (Cox & Vargas, 1966). The Field Research Program designs the testing and evaluation procedures for ongoing Center activities in schools and carries out additional special studies when necessary (Yeager & Lindvall, 1967). Effective use of computer data processing for the conduct of these activities is a

major tool, particularly in the development of computer management systems for adapting instruction to individual differences.

Experimental School Development. The primary focus of this program is to develop, test, revise, and study new educational procedures. A central focus is the development of school situations which are highly responsive and adaptive to the requirements of the individual learner. As prototype models are developed, experimental schools are established in which educational and learning processes can be studied and from which data can be obtained which contribute to instructional theory and to the improvement of curriculum materials and practices. Experience has indicated that there is an optimal size for a particular school undertaking--too small a project does not have enough impact in generating significant and sustained redesign of school conditions; too large a project does not permit intensive study or continual improvement based upon information feedback. The mass required is, however, still sizable, and the projects in this program, in order to be most effective, usually require additional resources beyond that of the Center. In some cases experimental school design can be planned for introduction into a cooperating school over a specified period of time. In other cases, especially when specialized materials and equipment or extensive classroom redesign is involved, schools will be invited to bring their classes into the Center's experimental classrooms. The work in this area is focusing on three major projects: The Individually Prescribed Instruction Project (Lindvall & Bolvin, 1967; Glaser, 1968), The Primary Education Project (Resnick, 1967), and The Responsive Environments Project (Moore & Anderson, 1968).

Overall, the Center's four program areas, Basic Learning Studies, Computer-Assisted Instruction Studies, Field Research, and Experimental School Development work toward an integrated research and development setting where each of the program areas can contribute to the work of the other.

Illustrative Activities

Under the space requirements of this report some illustrative, ongoing activities in each of the program areas of the Learning Research and Development Center will be briefly described rather than attempting to list and summarize in fewer sentences all ongoing Center work.

Basic Learning Studies

Language Comprehension Skills. Several pilot studies on the analysis of syntactic comprehension skills have been conducted which have led to the use of the Eye-Voice Span Technique (EVS) as a convenient means of studying segmenting behavior (Resnick, 1968). In the EVS procedure the subject reads a text projected on a screen. When he reaches a pre-determined word in the text the screen is blacked out, but the subject continues to "read" on for several more words. This procedure yields several scores for each subject. Most important for the work to date have been the subject's average EVS (i.e., the average number of words beyond the light-out position) and a count of the number of trials on which the subject stopped reading at a phrase boundary. The former is a measure of how far ahead, in purely quantitative terms, the subject is typically scanning. The latter is a measure of the kinds of syntactic units he is using as he reads. Measures of speed of oral reading and more refined syntactic scores can also be derived from the basic EVS data.

Studies completed during the past year have confirmed the findings of other investigators that both size of scanning unit and tendency to pause at syntactically appropriate phrases in the text increase with age (third grade to college). However, in the youngest readers there was no significant association between reading in longer units and reading in syntactically appropriate units. This lack of relationship could be due to the overwhelming attention new readers must give to the problem of simply recognizing the words. To explore this possibility an experimental condition was used in which college students read slides projected upside down in order to create a task analogous in perceptual difficulty to the third grader's. Under these conditions both length of unit and syntactic appropriateness declined drastically (to about the third grade level) but the association between the two scores was actually heightened. This finding suggests that once a relatively strong degree of syntactic control in reading is established (as it is assumed to be in college students), the introduction of perceptual difficulty will make it less manifest. However, if a subject is able to overcome the perceptual problem, he will automatically bring his syntactic responses back into play. In third graders, where the syntactic behavior is weak altogether, increased perceptual skill will not affect the syntactic character of reading units.

These findings suggest that training in speeded reading, which ought to extend average EVS, should have different effects on college and younger subjects. This hypothesis is being investigated in college students, using students in a university speed reading course as subjects.

A parallel study using young children is being planned. Also of interest is the relationship of various EVS measures to the subject's ability to predict missing words in a text (cloze procedure) and ability to answer questions based on the text. Both of these measures are aspects of "comprehension." An additional concern is the relationship of the EVS phenomenon to short-term perceptual memory, and studies are now being conducted to determine the extent to which subjects of different levels of reading still are actually "processing" language as they scan ahead.

Response Latency. A second area of investigation, response latency (Judd, 1968), is of relevance to instructional decision making since latency may provide a measure of learning strength after correct response frequency or response probability measures have reached an asymptote. It is known, for example, that retention is increased by overlearning, but specifically, how much overlearning is required for a particular individual? If individuals differ in the amount of practice for initial learning, it can be assumed that they also differ in the amount of overlearning practice required to achieve a desired degree of retention. The problem arises of how to decide when a subject or individual has received enough overlearning practice or when a student has reached a sufficient overlearning criterion. An error rate, or response probability measure, is of little value during this stage since the student has learned the response and is consistently correct; at this point, response latency may provide a basis for deciding when to discontinue overlearning practice. In order to investigate this problem an experiment was run under online computer control, which examined changes in latency over the course of learning a short list of paired-associate items.

The data obtained indicated that over the course of learning prior to the trial of last error, latencies showed little change and did not reflect the change in associative strength indicated by a substantial increase in correct response probability. There were no systematic differences between the latency of correct and incorrect responses during this period. In general, it appeared that latency was not a valid measure of learning during the early stages of this paired-associate task. In contrast, a significant finding was that subsequent to the trial of last error, there was a large and consistent reduction in latency. Since this reduction in latency accompanied overlearning practice, there is the suggestion that the increase in response speed during overlearning will provide a measure of the subject's degree of overlearning and might predict subsequent retention. The possibility that latency did measure overlearning was indicated further by the finding that those items which required a greater number of trials to reach criterion in initial learning tended to have longer latencies after the trial of last error.

Work is in progress to continue the evaluation of latency measures as indicators of overlearning and predictors of retention. An experiment underway involves sustained overlearning in a paired-associate task in order to establish whether or not response latencies reach a stable asymptote and whether or not this asymptote is related to the rate with which the item is initially learned. A subsequent experiment will control the amount of overlearning on the basis of latency measures and will measure retention of the material following a period of drill on interfering material. This will be done in order to attempt to correlate latency measures during overlearning with

subsequent retention. This research program has as its goal the control of retention by training to a latency criterion. The initial work will be concerned with simple paired-associate learning. It is anticipated that a parallel research program will be considered to investigate the utility of latency measures in concept learning situations.

Computer-Assisted Instruction Studies

Of importance to the work being carried out by the Computer-Assisted Instruction Studies Program is the design of experimental materials that can be presented to students via computer control. Therefore, one emphasis of the work on this program has been on the design of experimental courses and on the overall process of curriculum development from the design of materials by lesson writers through computer coding and computer implementation (Nemitz, 1968). The instructional strategy and presentation context of a program designed to teach basic number concepts to three- and four-year old children entitled "Introduction to Numbers" has been completed. Materials preparation, computer programming, and debugging of the first section of the program have been completed and initially tested. The student station used in presenting the curriculum content to the student consists of a touch-sensitive display (Glaser & Ramage, 1967), a slide projector and a speaker attached to a rapid-access audio unit. As a result of the initial tryout, the instructional strategy was revised, and the modified program retested with additional subjects. The new strategy, in addition to providing remedial and forward branching, includes extended review, when necessary, of previously learned numeral discriminations

and provision for the student to correct himself after receiving feedback information that he has initiated an incorrect response. This latter aspect of the instructional strategy increases the probability that the student will end each teaching frame with a correct response. Strategies for the remaining sections of the "Introduction to Numbers" program have been programmed for the computer and are currently undergoing tryout and evaluation.

A second program, "Timetelling," has undergone a number of revisions in terms of the instructional strategy employed. Currently, materials preparation is being completed. The student station planned for use with the timetelling program employs the touch-sensitive display, rapid access to audio messages, and a voice-key into which the student can speak his response. In contrast to the Numbers program, timetelling is designed to accumulate student response histories over relatively large portions of the program and to use them in making branching decisions. Of interest is an investigation of the depth and breadth of response history necessary to make instructional decisions.

Of interest in work with the timetelling course is comparison of the first CAI version of timetelling with other methods of teaching, employing simpler apparatus with less provision for branching strategies. A second version employs a free-standing portable laboratory teaching machine which provides auditory and visual stimuli, multiple-choice responses and aural responding through a voice-operated relay. The instructional sequence with this portable machine is similar to the CAI version, but the branching strategy is more limited, and multiple-

choice responses are required. A third version of the timetelling course employs a linear strategy. The student receives sound messages at various points in the program by operating a special audio-frame tape recorder. Visual presentation is made by means of a booklet in which responses to each page are made by marking over the answer with a chemically treated pen which confirms a response by making visable preprinted material (Glaser, Kaelin & Samuels, 1968). Course design is completed for the latter two versions of the timetelling course and materials preparation is underway.

As has been the plan of the work on Computer-Assisted Instruction, the experimental courses designed will continue to serve as vehicles for experimental studies to evaluate instructional strategies, human engineering aspects of student consoles, and computer language design. The depth of response history which needs to be stored to effectively adapt to individual differences is a question of interest. Indices of this history will be investigated, such as error patterns, learning rates, and response latency. The amount and kind of history storage required is a significant area for investigation because it determines required investment in computer hardware and software. In addition, the characteristics of feedback and reinforcement parameters required to actively interest young children in automated stations will be studied.

Field Research

Computer Management. One of the major activities of the Field Research Studies Program has been the design and implementation of a data management system for both classroom management and research purposes. After three years of development, the Center's Individually

Prescribed Instruction Project had reached a point of development where information requirements, in terms of student classroom management, demanded that new procedures be developed to provide both the Center project staff and the classroom teacher with rapid access to large amounts of information on student progress. To meet this need a computer management system was designed that would permit the teacher to operate online with the University Computer Center at any given time in order to retrieve information concerning the students with whom she is working.

There are three locations where the hardware elements of the system are housed: (1) at the school--an optical scanner and card punch, a typewriter console with a card reader; (2) at the Center--a typewriter terminal; and (3) at the University of Pittsburgh Computer Center--an IBM 360/50 Computer. This hardware configuration is connected by telephone lines and provides the capabilities necessary for meeting the needs of both the teacher and the researcher. As student data is generated at the school it is transmitted to the University Computer Center and stored on disc and magnetic tape. The information on disc can be queried by the classroom teacher to obtain background and status data about the student via the typewriter console in a matter of seconds or minutes. The communication terminal located at the Center provides researchers with the capability of carrying out, in a matter of hours, studies requiring large amounts of data that would have originally taken weeks to gather and analyze.

Of considerable importance during the initial period of development of the system was the specification of the types of information

required and the formating of this information. It was only after this very time consuming activity was completed that efforts could be directed to developing and testing the required computer programs necessary for making the system operational. To date, a few classroom management programs are now running, and the retrieval and analysis programs for the research and evaluation aspects are operational.

One of the goals of the system is to develop a procedure for using available student data to develop for each student a suggested prescription for consideration by the teacher. It is through this constant feedback of information concerning the instructional operation of the school that teachers and researchers can endeavor to improve student performance.

Rate of Learning. Another area in the Field Research Studies Program that has been of continuing interest is the study of problems associated with measuring student rate of learning and student factors associated with it (Yeager & Lindvall, 1967; Wang, 1968). Although studies on this variable have been undertaken in laboratory settings, little has been done to investigate it in an ongoing classroom situation. Undoubtedly, one important reason for the paucity of studies of rate of school learning is the difficulty of establishing a usable measure of rate and in exercising some control over the number of factors that can affect this variable. Perhaps an equally important reason is the difficulty encountered in implementing an operational instructional system where provision is made for students to progress at individual rates. Since the Center's Individually Prescribed Instruction Project provides a setting where students are permitted to progress at individual rates,

a number of studies have been undertaken that examine the characteristics of various rate measures.

The types of rate measures examined include days per unit, units per year, skills per year, achievement per day, work pages per day, and skills per day. As individual rate measures, each of the measures presents some limitations in terms of comprehensiveness. These measures have been studied in terms of their meaningfulness, utility, and relationship to selected student variables. Each of these measures has been examined in terms of its relationship to student characteristics such as intelligence, mathematics and reading achievement scores, attention scores, and attitudes towards materials and subject areas. None of the rate measures was significantly related to any of these variables nor were composite rate measures significantly related to a single student variable or group of student variables.

These results suggest that rate of learning is not a general characteristic of the learner and support the contention that the rate of learning is specific to a given learning task. Plans are now being formulated to continue the investigation of student rate measures and their relationship to student factors and to aspects of the instructional system. As these relationships become known, the characteristics of the instructional system can be modified to maximize the progress of the individual student.

Experimental School Development Program

Individually Prescribed Instruction. One of the major activities of the Experimental School Development Program is Individually Prescribed

Instruction (IPI) (Lindvall & Bolvin, 1967; Glaser, 1968). This project was initiated as a feasibility study to determine if it were possible to develop a system of procedures that would produce an educational environment which would be highly responsive to differences among children. The individualization that is being provided for, during the initial years of development, involves individualized lesson plans, individualization of the materials and instructional techniques provided, and achievement of a required level of subject matter mastery for each student.

In order to develop and implement the IPI system, cooperative relations with the Baldwin-Whitehall School District were established and the Oakleaf Elementary School was designated as a laboratory school for the development and testing of the IPI system. Currently the project involves students spending a portion of each school day engaged in IPI procedures in mathematics, reading, and science. Typically, a student spends fifty minutes in each of these areas per day and the remaining time in subject areas taught through more conventional methods.

In each of the IPI curriculum areas, sequences of behaviorally stated objectives have been spelled out and material selected to enable students to achieve mastery of each of the objectives. These materials were not obtained from any single source, but rather from a large number of sources identified through an intensive survey of existing materials. One criterion that influenced the selection of these materials, aside from the specific behaviors that they were to teach, was the extent that the materials could be utilized by the student in studying independently of the teacher's assistance. Whenever commercially prepared materials

proved to be unavailable or inappropriate, the Center's staff and teachers prepared materials. Types of materials that have proven useful have included worksheets, individual readers, programmed textbooks, and taped lessons played on cartridge-loading tape-playback devices. In the science program the utilization of taped instructions has permitted students to conduct a series of simple experiments on an independent basis. In reading, considerable attention has been given to the student engaging in independent reading activities in which he is responsible for selecting his own books from either the library or book shelves in his own room on the basis of his interest. Such readings are then discussed with a teacher and with fellow students. By following this procedure, materials are assembled that allow for a maximum use of individual study but with some utilization of small group instruction, large group instruction, and individual tutoring by the teacher.

At the beginning of the school year, each student is given a series of placement tests for the purpose of assessing his entering behavior and determining the level at which he should begin work in each content area. In this manner both inter- and intra-individual differences in level of achievement are accounted for in the mathematics, reading, and science curriculums. The student is then assigned work in the unit in the curriculum continuum for which he indicated lack of mastery, but for which he has the necessary prerequisite abilities. Prior to starting work in the unit the student is given a unit pretest constructed to evaluate his mastery of the specific objectives included within a particular unit. The student's performance on this pretest is then examined and, as a result of this

diagnosis, a series of learning experiences uniquely suited to the individual's competencies is prescribed.

These learning experiences consist of work pages or other instructional materials. A particular prescription contains enough materials to provide a student with work lasting from a single day to a week, depending on the student's ability, the type of units being studied, and the number of experiences prescribed. The student "fills" his prescription by first obtaining materials from the learning center and then working independently, receiving teacher assistance when needed, or in large and small groups under the direction of a teacher. Upon completion of a given learning experience, a student presents his work to a para-professional to grade and record. As the student progresses through each set of experiences, his achievement is evaluated in terms of his performance on the lesson material completed and a series of curriculum-embedded tests.

When a student completes the work for a given unit, which consists of a series of sequential prescriptions, a unit posttest is assigned. If a student demonstrates mastery of the unit on the posttest, he is assigned a new unit of work, if not, a new prescription is written for those objectives where assistance is indicated. It is through this process of ccntinual re-evaluation that a student progresses from one learning task to another at a rate commensurate with his needs and abilities.

As evident from this description of IPI, the teacher's role is somewhat different from that found in more traditional classrooms. The

teacher spends a considerable amount of time in studying the progress of individual students and in developing individual learning experiences fitted to the needs of each student. In this role the teacher is not only a source of information, but also a diagnostician and consultant on individual learning requirements.

The work of the IPI project to date points to the feasibility of this type of procedure as one system for achieving the individualization of instruction. Further work remains to be done: (1) to study how learning proceeds in such an educational environment, and (2) to redesign the system so that it becomes increasingly effective in both (a) adapting instruction to learner requirements and (b) allowing the learner to attain the various goals of elementary education. IPI holds promise for positive change in the classrooms of the nation, and it is the intent of the Center to more fully develop all the necessary components of the IPI model in order to fulfill this promise.

Primary Education Project. The Primary Education Project (PEP) is a new experimental school project of the Center. PEP has as its aim the development of individualized curriculum and a school organization that will serve children in a continuous program beginning at age three and running through the primary grades. Particular emphasis in this work will be on the needs of urban culturally-deprived children. Basic to the project is the assumption that the full potential of an early start in formal education can only be realized when the entire school environment, at least through the primary grades, can be made more responsive to the children's needs. PEP is a joint effort of the University

of Pittsburgh, Pittsburgh Public Schools, and the General Learning Corporation. The Center is responsible for the research and development activities leading to the design of curriculum, classroom management procedures, and ultimately for the conduct of the general evaluation of the project's effectiveness. The project is now operating on a pilot basis in a Pittsburgh elementary school chosen for its unusually heterogeneous urban population. Children currently involved in this project are in the preprimary headstart classes and the kindergartens and in one first grade class. During the 1968-69 school year the project will continue to serve preschool and kindergarten children plus the first grade class. In each subsequent year one additional grade will be added, at least through the third grade.

PEP's major attention in its first two years will be twofold: (a) curriculum design and implementation for preschool and kindergarten, and (b) studies in shaping motivation and attention in learning. One of PEP's major contributions will be a rigorous methodology for curriculum design that is applicable not only to preschool, but to curriculum projects at a variety of levels and in a number of subject areas (Resnick, 1967). The procedure begins with the analysis of behaviorally stated curriculum objectives in such a way as to identify a hierarchy of prerequisites or component behaviors for the objectives. That is, skills or concepts which a child would need to have before he could successfully be taught the new objective. Each analysis specifies one or several sequences of instructional objectives.

The project staff is now engaged in component analysis work in a number of areas considered important in the preschool and kindergarten

curriculum. These include: early quantification skills, classification, plan following, motor skills, and certain language skills. On the basis of these analyses, hierarchically sequenced sets of criterion-referenced tests will be constructed. These tests will be the central vehicle for monitoring students' progress. The curriculum will be defined for a teacher by giving her the sequenced set of tests and instructing her to teach her children to pass all the tests. This strategy places a great deal of the burden on the classroom teacher while obtaining substantial school control over the curriculum through these tests. The PEP staff believes that the combination of control of curriculum objectives through tests with freedom of instructional tactics may be an effective means of capitalizing on teachers' strength and also of preventing them from feeling overwhelmed by a too complex system enforced from without. In addition, it is expected that a system defined by tests of mastery performance rather than by specific lessons, will be much easier to revise and modify as more knowledge about children's learning patterns is accumulated.

The basic thrust of PEP's work is based on the hypothesis that intelligence is, by and large, learned by and responsive to experience. To adequately test this hypothesis, a sustained attempt is required to increase the rate at which children acquire, one after another, the key components of intelligence. For such a test it is important that the hierarchies guiding instruction are valid and reflect the natural order in which skills and concepts are acquired. Component analyses of the kind described above take account of existing research on children's learning and cognitive performance. The component hierarchies and

resulting teaching sequences must therefore be empirically validated before they can be regarded as authoritative. Concurrently, with the use of curriculum based on component analyses in the school, the project staff will undertake formal validations of the hierarchies described in the analyses. Two strategies will be used. In one, a program of extensive testing on individual components will be followed by examination of the relationships holding between test items for individual children--a non-linear form of scaleogram analysis. A second strategy involves teaching individual children each component that they lack according to the analyzed hierarchy. Such instruction should lead to the establishment of the terminal behavior with relatively little difficulty and would constitute an experimental validation of the hierarchy.

PEP's concern with shaping motivation and attention is based upon the observation that one of the most striking characteristics of young children is their distractability. Some older children, particularly the disadvantaged, the retarded, and the emotionally disturbed possess this characteristic. These children often do not follow directions, and in general show a low level of impulse control. In short, they seem to have problems in orienting themselves in learning. Disadvantaged children typically enter school with still another difficulty because of the characteristic of the interaction with adults at home. They are not used to working with recognition such as approval and disapproval, and the pleasure of completing a task successfully. This is probably because there has been such little occasion for success, and

recognition of such at home. These children, in other words, are not motivated to work for the two major kinds of rewards that the school offers: pleasure in doing a task well and social approval. Given this fact alone, it is not surprising to find so many failing in school work. Techniques for systematically and efficiently dealing with deficits of this kind have been developed and applied in a number of classroom settings, particularly among retarded and slow learners. These techniques involve the use of social and other reinforcers in a manner that is systematically contingent on the child's performance of desired behaviors. In the nursery school, however, while certain social behaviors have been studied and modified, very little attention has been paid to the shaping of such behaviors as concentration and task oriented attention in preschool children.

PEP is currently experimenting with three different forms of applied reinforcers. In one of its preschool classrooms attention to conceptual tasks earn time at more favored activities, such as water and blocks. In the first grade "Reading Readiness Class" children earn tickets during their work period which can be spent for the "rental" of play equipment during recess. In a third classroom, social reinforcement or attention is being used in an attempt to encourage a three-year old child to initiate more social contact with adults and peers. PEP plans to continue studies of these and other forms of behavior modification in the classroom addressing itself in particular to the shaping of attention, direction following, and self-planning skills. PEP will also study systematically the problems involved in gradually reducing

extrinsic reinforcers while still maintaining desirable levels of motivation and attention. This question has been given only peripheral attention in the applied behavior modification literature to date, and represents a major need before reinforcement principles can be fruitfully applied in a wide variety of settings.

Conclusion

As one looks back on four years of operation of the Learning Research and Development Center, the work of the Center faculty appears to emphasize what they consider to be themes of investigation which are of special significance to research and development relevant in education. These themes are the following: (1) The importance of contact with scientists, engineers and subject matter scholars and the mutual interplay between basic and developmental activities so that a body of technology can be made available for the design of educational practices. (2) The importance of adapting educational environments to the requirements and requests of the individual learner. (3) The significance of evaluation, not only for the assessment of student progress in the course of his education, but also for the monitoring of educational procedures and materials in order to redesign and improve them, and to put their respective contributions to the educational process into the proper perspective.

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FOOTNOTE

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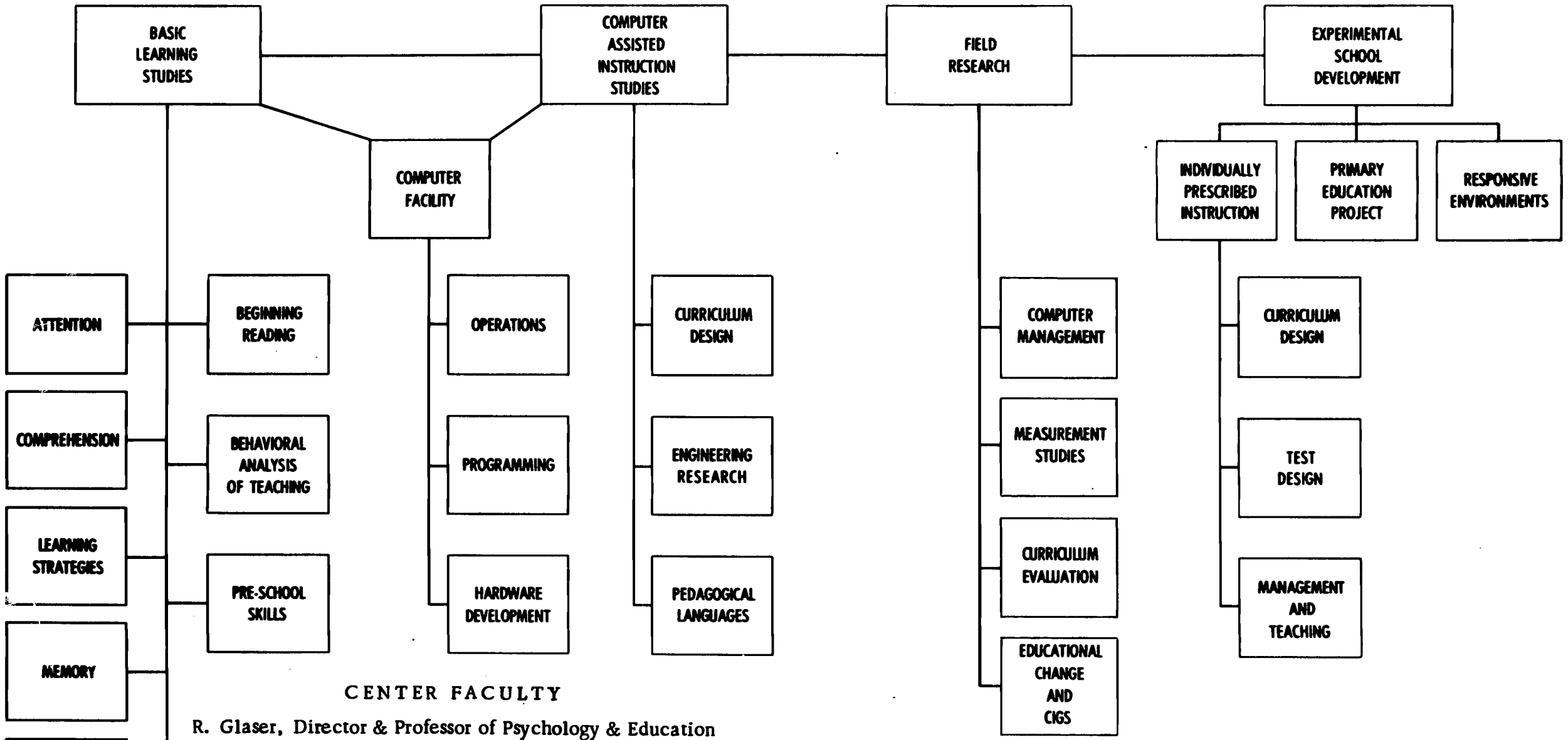

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